DOCUMENT RESUME

ED 448 132 SP 039 645

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TITLE Cognitive Illusions as Hindrances to Learning Complex Environmental Issues.
PUB DATE 2000-11-15
NOTE 7p.; Paper presented at the Annual Meeting of the Mid-South Educational Research Association (Bowling Green, KY, November 15-17, 2000).
PUB TYPE Reports - Research (143) -- Speeches/Meeting Papers (150) -- Tests/Questionnaires (160)
EDRS PRICE MF01/PC01 Plus Postage.
DESCRIPTORS *Environmental Education; Global Warming; Higher Education; *Science Education
IDENTIFIERS *Ozone Depletion

ABSTRACT

This study examined the effectiveness of an environmental science course for teaching college students about the ozone depletion problem. In the spring of 2000, students in the course, "Life in the Environment," were pretested and posttested with a 38-item questionnaire consisting of 3 sets of Likert-style statements plus multiple choice questions. The first set of questions focused on the results of ozone depletion. The second set focused on causes of ozone depletion. The third set targeted ways to lessen ozone depletion. Five of the multiple choice questions targeted factual information, and the last two focused on opinions. Overall, posttest scores were lower than pretest scores. Students showed a strong tendency to conflate cause and effect relationships between several different environmental issues which were really not related. This was especially pronounced for global warming and ozone depletion. The results reveal the difficulty in guiding students to construct proper concepts for complex subject matter by means of traditional, direct instruction methods. The questionnaire, which makes up the majority of the document, is appended. (SM)

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Cognitive Illusions as Hindrances to Learning Complex Environmental Issues

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Paper presented to the Mid-South Education Research Convention, Bowling Green, KY, November 15, 2000

SP039645

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Cognitive Illusions as Hindrances to Learning Complex
Environmental issues

Teaching complex issues in science is a challenge that has become increasingly important over the past few years due to educational reform efforts such as the *National Science Education Standards* (1996), and to increased emphasis on critical thinking and problem solving skills by standardized exit tests used by more and more states. Also, the emergence of constructivist theory as a major paradigm over the last part of the 20th century has forced educators to deal with the fact that scientific knowledge cannot be merely transmitted from teacher to student; the student will necessarily, and unavoidably, create his own understanding of scientific topics, and this can lead to knowledge which is at variance with accepted scientific thinking.

The purpose of this study was to determine the effectiveness of an environmental science course for teaching the ozone depletion problem. Ozone depletion represents a complex environmental issue for which scientific understanding is continually evolving, and which also involves a large number of variables that can be cognitively challenging for students. In this study students were pre- and post-tested in the Spring, 2000 semester with a 38 item questionnaire consisting of three sets of Likert style statements, plus multiple choice questions. The first group of statements focused on results of ozone depletion, the second set on causes of ozone depletion, and the third set targeted ways to lessen ozone depletion. Five of the multiple choice questions targeted factual information, and the last two focused on opinions. The Likert style rating ranged from "I am sure this is correct" to "I am sure this is wrong".

The course, *Life in the Environment*, focused on current environmental issues, including global warming and ozone depletion. The instructional format was lecture/discussion supplemented by Power Point presentations.

For science instruction, a critical problem has been misconceptions held by students (Groves and Pugh, 1999; Boyes et al., 1993). A part of this problem is that students sometimes create simplistic mental models when trying to make sense of complex issues such as global warming and ozone depletion. A factor which can lead students to adopt such mental models comes from the tendency of strongly held initial opinions to be "resistant to changes because they influence the way that subsequent information is interpreted" (Slovic, 1987). This leads to what Nicholls (1999) calls cognitive illusions:

> "These are analogous to optical illusions in leading to errors we commit without knowing we are doing so, except they arise from our difficulties in quantifying and dealing with probabilities, uncertainty, and risk".

Nicholls points out that such illusions are not just due to ignorance, but because the human mind's capacity to deal with complex issues is limited, and leads to the tendency to resort to simple rules of thumb or heuristics.

Overall, post-test scores were lower than pre-test scores, and students showed a strong tendency to conflate cause/effect relationships between several different environmental issues which are not actually related. This matches with previous research, and indicates that as students become more generally aware of environmental problems, they tend to assume relationships that are not correct. This is especially pronounced for global warming and ozone depletion, with most students incorrectly believing that ozone depletion contributes to global warming when the reverse is true, that global warming may increase ozone depletion. These results reveal the difficulty in guiding students to construct proper concepts for complex subject matter by means of traditional, direct instruction methods, even with the use of presentation devices such as Power Point. Students must be challenged to see that their prior assumptions do not properly accord with current explanations for complex problems, and that simple explanations for phenomena are not always possible.

Analysis of Pre- and Post-test Subscale Results

	Pre-Test			Post-Test		
Subscale #:	1	2	3	1	2	3
Mean:	5.35	5.85	5.46	4.54	5.92	5.12
SD:	1.83	1.71	2.21	2.18	1.44	1.90

Subscale #1: Items 1 - 10
Subscale #2: Items 11 - 20
Subscale #3: Items 21 - 30

T-test Results (Comparison of Pre-Post Subscale data):

Subscale #1:	$p < .02$
Subscale #2:	NS
Subscale #3:	NS
Overall:	NS

Specific Knowledge Items (#31 - 35) (Percent correct):

Item #:	Pre-test %	Post-test %
#31:	60%	43%
#32:	28%	25%
#33:	33%	18%
#34:	34%	60%
#35:	10%	8%

#36. The ozone hole problem is getting worse (percentage of agreement with statement):

Pre-test	Post-test
79%	88%

Ozone Layer Questionnaire

Scoring: A = I am sure this is right,
B = I think that this is right
C = I think that this is wrong
D = I am sure this is wrong

* Please answer all questions; leave no blanks.

1. If the ozone layer problem becomes worse, our weather will get hotter.
2. If the ozone layer problem becomes worse, some of our tap water will be unsafe to drink..
3. If the ozone layer problem becomes worse, there will be more flooding.
4. If the ozone layer problem becomes worse, there will be more water pollution.
5. If the ozone layer problem becomes worse, more people will get skin cancer.
6. If the ozone layer problem becomes worse, there will be more insect pests.
7. If the ozone layer problem becomes worse, there will be changes in the world's weather.
8. If the ozone layer problem becomes worse, the world's ice caps will shrink in size.
9. If the ozone layer problem becomes worse, there will be more air pollution for us to breathe.
10. If the ozone layer problem becomes worse, more ultraviolet rays will reach the earth's surface.

11. The ozone layer problem is made worse by too much sunlight reaching the earth's surface.
12. The ozone layer problem is made worse because too much carbon dioxide is entering the atmosphere.
13. The ozone layer problem is made worse by man-made CFC (freon) gases entering the atmosphere.
14. The ozone layer problem is made worse by too much ultraviolet light reaching the earth's surface.
15. The ozone layer problem is made worse by gases from rotting wastes.
16. The ozone layer problem is made worse by radioactive waste from nuclear power.
17. The ozone layer problem is made worse by acid rain.
18. The ozone layer problem is made worse by gas from artificial fertilizers.
19. The ozone layer problem is made worse because sunlight reflected from the earth's surface cannot escape into space.
20. The ozone layer problem is made worse by the use of certain pesticides.

21. The ozone layer problem can be lessened by using nuclear instead of coal power stations.
22. The ozone layer problem can be lessened by keeping trash picked up.
23. The ozone layer problem can be lessened by using unleaded gas.
24. The ozone layer problem can be lessened by stopping the use of CFC gases.
25. The ozone layer problem can be lessened by planting more trees.
26. The ozone layer problem can be lessened by recycling household trash.
27. The ozone layer problem can be lessened by producing less carbon dioxide and methane.
28. The ozone layer problem can be lessened by protecting rare plants and animals.
29. The ozone layer problem can be lessened by launching fewer rockets and missiles through it.
30. The ozone layer problem can be lessened by stopping the use of certain pesticides.

31. The ozone layer is located
    a) out in space, above the earth's atmosphere
    b) about 10-20 miles above the earth's surface
    c) underground
    d) in the air we breathe

32. The thickness of the ozone layer is
    a) 1 cm
    b) 1 foot
    c) 1 mile
    d) 10 miles
    e) 100 miles

33. The ozone holes are about the size of
    a) pie plates or table tops
    b) football fields
    c) a typical parish or county
    d) Louisiana
    e) the U.S.

34. The ozone layer is made up of
    a) UV rays
    b) chemicals
    c) air
    d) oxygen molecules
    e) carbon dioxide molecules

35. How many ozone holes are there?
    a) 1
    b) 2
    c) 3 to 10
    d) hundreds
    e) thousands

36. The ozone hole problem is
    a) getting better
    b) getting worse
    c) staying the same
    d) do not know its condition

37. The ozone hole problem
    a) is a real problem that requires our attention
    b) doesn't really exist; has been created for political reasons

****

38. Grade level:
    a = 9th b = 10th c = 11th d = 12th

39. Gender: a) male b) female

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